Configuration and Selection of Microwave Generators

Industrial Microwave + Plasma Systems

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Microwave Generators

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Configuration and selection of microwave generators

Microwave generators are integrated solutions designed to generate and transmit microwave power.

Microwave generators are typically available in two configurations:

- Integrated Microwave Generators or
- Modular Microwave Systems

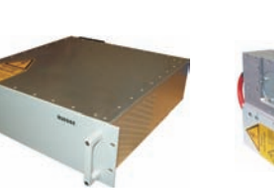
e.g. integrated microwave generator: MG0500D-210TC

An integrated microwave generator is supplied in a single cabinet, which contains of all generator systems and subcomponents.

A modular microwave generator system is supplied as separate components including but not limited to a power supply, magnetron head, and cable assembly.

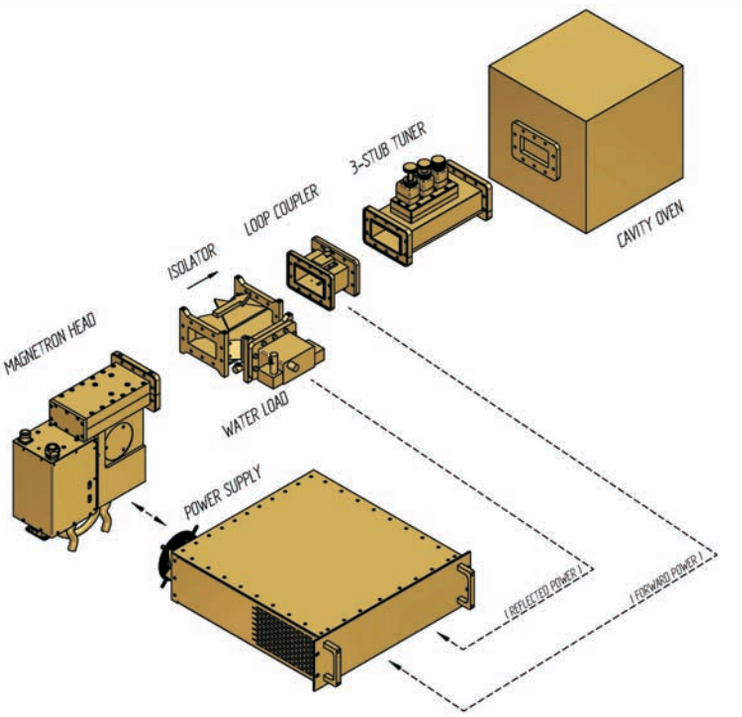
Both systems require the same basic installation procedure:

connecting the external waveguide, electrical mains, cooling water lines and fieldbus interface.



e.g. modular microwave generator system: MX-Power Supply MX2000D-112KL and Magnetron Head MH2000S-215BB

A typical microwave system is illustrated in Figure 1 below:



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Microwave Power Supplies:

The power supply provides the voltage and current to power the magnetron, and depending on its design, provides a fieldbus interface for system control or integration into a larger system. The three most common power supply types used in microwave heating applications include: switch-mode, conventional /inductive (LC), and pulse. Power supplies are primarily application dependent, but cost is often a considerable factor.

- **Switch-mode power supplies** convert an AC input voltage to a low ripple adjustable DC current. The primary advantages of switch-mode power supplies are their compact size, stability and low current ripple, which produces a high quality, narrow bandwidth output spectrum.

  [MX-Series: Switch Mode Power Supplies]

e.g. Microwave Switch Mode Power Supply
MX2000D-112KL

- **Conventional/Inductive (LC) power supplies** are offered in different styles, but are similar in construction. They include transformers (high voltage and filament), capacitor(s), and diode(s). The most common types include full-wave doubler, half-wave doubler and full-wave rectified. The advantages of an inductive power supply are their robust build quality and the relative cost compared to switch-mode or pulse power supplies. Another benefit is their ability to operate in generally poor environmental conditions.

  [MC-Series: LC-Power Supplies]

e.g. LC Microwave Power Supply, MC-Series
MC3000B-114AA

- **Pulse power supplies** represent the latest technology for microwave power supplies. As their name implies, they are able to operate a magnetron in pulse mode, which achieves higher peak output powers within a specified time period. Many pulse power supplies also have the capability to operate the magnetron in “CW” or continuous mode as well.

  [MP-Series: Pulse Power Supplies]

e.g. Microwave Pulse Power Supply
MP1003G-112UL

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Magnetron Head:

The magnetron head consists of a magnetron, waveguide launcher, and filament transformer all connected and prewired to generate and transmit microwave energy. All subsystem components have been designed to offer the highest level of performance, stability, and system efficiency. Microwave heads can be supplied with many different options and configurations based upon the application and user specifications.

[MH-Series: Magntron Heads]

e.g. Magntron Head MH2000F-216CM
MH-Series, 2450 MHz, Open mounted

e.g. Magnetron Head MH2000S-215BB
Compact Power Head, MH-Series, 2450 Mhz,

e.g. Magnetron Head MH020KS-310CN
Microwave Power Head, MH-Series, 2450 MHz

e.g. Magnetron Head MH100KS-510CF
Microwave Power Head, MH-Series, 915 MHz

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Waveguide Components:

It may be necessary to add additional waveguide components to the microwave transmission line for a variety of reasons. The most common waveguide components are described below and their location in the transmission line is illustrated in Figure 1 above.

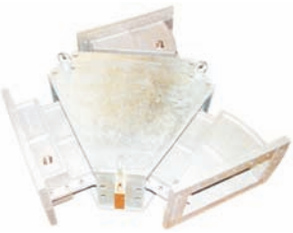
Isolators/Circulators:

A waveguide circulator is a 3-port devices utilizing ferrite technology (magnets) to selectively direct microwave energy to a specific port based on the direction of wave propagation. An isolator is a circulator with an absorbing load attached to one port. An isolator serves two main functions in a microwave circuit:

1) It protects the magnetron from reflected microwave energy.
2) Provides the magnetron with a matched-load for efficient generation of microwave energy.

Isolators are typically located closest to the magnetron (magnetron head) in a standard system configuration. Please reference Figure 1.

e.g. Isolator MW1006A-210EC
6 kW / 2450 MHz / WR 340



e.g. Circulator 1200197
100 kW / 915 MHz / WR 975

Directional Couplers :

A directional coupler is a waveguide component used to sample power from the transmission waveguide to measure frequency, power, or other system performance metrics. Directional couplers are most commonly used to measure forward and/or reflected energy. Their output is an attenuated RF signal that can be measured in multiple ways. The most common method is to measure the sampled energy with a power meter and power sensor attached to the measuring port of the directional coupler. The power sensor, which is calibrated for a specific frequency range and attenuation level, interprets the signal present at the couplers output and sends this information to the power meter for display. Another common measuring method is to use a detector diode attached to the measuring port of the coupler. The diode outputs a voltage, typically in the mV range, which proportional to the sampled energy. Output power is interpreted from the diodes characteristic curve.

e.g. Directional Coupler MW7010A-260FD
2450 MHz / WR 284

e.g. Directional Coupler MW7018A-260CD
915 MHz / WR 975

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Waveguide Components:

Tuners

A waveguide tuner is used for matching of the load impedance to that of the source, thereby reducing reflected power and maximizing the coupling power to the load/product. A tuner functions as an impedance matching device by manipulating the EM fields inside the waveguide by adjusting the depth of metal stubs placed at specific guide lengths.

Tuners are classified as either being “manual”, in which the stubs are manually adjusted into the waveguide, or as “automatic”, in which the stubs are attached to a motor, which is controlled by algorithms designed that automatically adjust the position of the tuner stubs for maximum power transfer.

e.g. 3-Stub-Tuner MW2010A-260EF
2450 MHz / WR 340

e.g. 3-Stub-Tuner MW2006A-260CF
896 MHz / 915 MHz / WR 975

e.g. Automatic Tuner MW2008H-260EC
TRISTAN / 2450 MHz / WR 340 / 20 kW

e.g. Motorized-Tuner MW2004J-260ED
2450 MHz / WR 340

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Waveguide Components:

Waveguide:

Waveguide size depends on operating frequency, power rating and cost. Table 1 list the various waveguide sizes commonly used in industrial microwave systems.

The ISM (industrial, scientific and medical) frequencies most commonly used for microwave heating include 2450 MHz (S band), 915/896/922 MHz (L band) and 5.8 GHz (C band).

Frequency Band	Frequency Range	Waveguide Size	
		EIA (USA)	IEC (Europe)
L	1 - 2 GHZ	WR975	R9
S	2 - 4 GHz	WR430	R22
		WR340	R26
		WR284	R32
C	4 - 8 GHz	WR159	R58

Table 1:

Although there is no published standard waveguide size for 2450 MHz system, WR284 and WR340 are most commonly used for power levels up to 10 kW, and WR430 for power levels of 15 kW to 30 kW. Standard flange dimensions accompany each waveguide size with a “flat/contact” flange being the most popular type for industrial heating applications followed by a “choke” flange, which is more common in communication applications.

Waveguide Material:

Waveguide is typically constructed from one of three materials: aluminum, copper and stainless steel. Aluminum is the most commonly used material and chosen primarily for its overall performance characteristics and low cost. Copper is used in specialty applications where conductivity and heat loss are the main concerns. Stainless steel is often used in food processing systems and pharmaceutical applications, which sanitation requirements are present.

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Microwave System Design:

Designing a microwave system begins by determining the following two main system components, the microwave source and load/cavity.

Microwave Source Considerations:

1) Frequency
2) Output Power Level
3) Frequency Stability / Output Ripple
4) Form Factor
5) Control
6) Cost

Microwave Load Considerations:

1) Cavity Type
   a. Multi-mode
   b. Resonant

2) Applicator Type

It should be noted that a variety of factors can influence the design and the correct microwave generator for use with a particular application. Muegge GmbH has extensive experience in the design, integration, and production of complete microwave generator systems, magnetron heads, power supplies and waveguide components and applicators. Our microwave engineers, plasma physicists, process engineers and system experts are prepared to assist you in determining the best microwave system and components for your application.

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About MUEGGE GmbH:

MUEGGE is the leading international manufacturer and provider of plasma source technologies, industrial microwave heating systems and the related components. For over 25 years, MUEGGE has developed, produced and supplied high-quality microwave CW and Pulse solutions for applications which require power ranges of 300 W to 100 kW at frequencies of 915 MHZ, 2450 MHz and 5800 MHZ. MUEGGE continues to develop and integrate industry leading microwave power solutions that are optimized and integrated into state-of-the-art technologies. The most demanding requirements are met by MUEGGE's advanced systems, plant, and process technologies resulting in an integrated concept that is based upon our scientific and technological experience.

MUEGGE's services range from the development of process engineering and plant engineering systems to construction, assembly, plant start-ups and comprehensive customer support. Its key products include both components and plasma sources based on microwave plasma, such as a high-performance remote plasma source to create radicals (rapid reactive radicals technology) for use in the semiconductor industry.

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